Enceladus Scatterometry Rev 061

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- Sequence: s38
- Rev: 061
- Observation Id: en_061_1
- Target Body: Enceladus

1 Introduction

This memo describes one of the Cassini RADAR activities for the s38 sequence of the Saturn Tour. A sequence design memo provides the science context of the scheduled observations, an overview of the pointing design, and guidelines for preparing the RADAR IEB. A 3-hour warmup occurs first using the parameters shown in table 4.

2 CIMS and Division Summary

CIMS ID	Start	End	Duration	Comments
061OT_WARMUP4EN002_PRIME	2008-072T03:16:12	2008-072T03:31:12	00:15:0.0	Warmup for scatterometry and simultaneous radiometry of icy satellite.
061OT_WARMUP4EN001_RIDER	2008-072T03:31:12	2008-072T14:36:12	11:05:0.0	Warmup for scatterometry and simultaneous radiometry of icy satellite.

Table 1: en_061_1 CIMS Request Sequence

Each RADAR observation is represented to the project by a set of requests in the Cassini Information Management System (CIMS). The CIMS database contains requests for pointing control, time, and data volume. The CIMS requests show a high-level view of the sequence design.

The CIMS requests form the basis of a pointing design built using the project pointing design tool (PDT). The details of the pointing design are shown by the PDT plots on the corresponding tour sequence web page. (See https://cassini.jpl.nasa.gov/radar.) The RADAR pointing sequence is ultimately combined with pointing sequences from other instruments to make a large merged c-kernel. C-kernels are files containing spacecraft attitude data.

A RADAR tool called RADAR Mapping and Sequencing Software (RMSS) reads the merged c-kernel along with other navigation data files, and uses these data to produce a set of instructions for the RADAR observation. The

Division	Name	Start	Duration	Data Vol	Comments
a	distant_warmup	00:00:0.0	11:23:0.0	10.2	Warmup
b	distant_radiometer	11:23:0.0	00:03:0.0	0.2	Off-target radiometer
c	distant_scatterometer	11:26:0.0	00:00:30.0	0.9	Scatterometer target-center stare with tone
d	distant_radiometer	11:26:30.0	00:00:30.0	0.0	Off-target radiometer
e	scat_compressed	11:27:0.0	00:05:0.0	1.3	Off-target scatt compressed 9 dB calibration
f	distant_radiometer	11:32:0.0	01:10:30.0	4.2	radiometer raster and filler
g	scat_compressed	12:42:30.0	00:05:0.0	1.3	On-target scatt compressed 9 dB calibration
h	distant_scatterometer	12:47:30.0	00:17:30.0	231.0	Scatterometer target-center with tone
i	distant_radiometer	13:05:0.0	00:03:0.0	0.2	Closing radiometry
Total				249.2	

Table 2: Division summary. Data volumes (Mbits) are estimated from maximum data rate and division duration.

Div	Alt (km)	Slant range (km)	B3 Size (target dia)	B3 Dop. Spread (Hz)
a	646612	off target	8.39	off target
b	216255	off target	2.81	off target
c	214058	off target	2.78	off target
d	213691	off target	2.77	off target
e	213324	off target	2.77	off target
f	209645	off target	2.72	off target
g	156049	156049	2.03	559
h	152125	152125	1.98	566
i	138262	138262	1.80	590

Table 3: Division geometry summary. Values are computed at the start of each division. B3 Doppler spread is for two-way 3-dB pattern. B3 size is the one-way 3-dB beamwidth

Name	Nominal	Actual	Mismatch	Comments
mode	radiometer	radiometer	no	
start_time (min)	varies	0.0	no	
end_time (min)	varies	683.0	no	
time_step (s)	varies	3600.0	no	Used by radiometer only modes - saves commands
bem	00100	11111	yes	
baq	don't care	5	no	
csr	6	6	no	6 - Radiometer Only Mode
noise_bit_setting	don't care	4.0	no	
dutycycle	don't care	0.38	no	
prf (Hz)	don't care	1000	no	
tro	don't care	0	no	
number_of_pulses	don't care	8	no	
n_bursts_in_flight	don't care	1	no	
percent_of_BW	don't care	100.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	0.248	0.248	no	Kbps - set for slowest burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 4: en_061_1 Div a distant_warmup block

Name	Nominal	e	g	Mismatch	Comments
mode	scat_compressed	scat_compressed	scat_compressed	yes	
start_time (min)	varies	687.0	762.5	no	
end_time (min)	varies	692.0	767.5	no	
time_step (s)	don't care	30.0	12.0	no	Set by valid time calculation
bem	00100	00100	00100	no	
baq	3	3	3	no	3 - PRI summation
csr	1	1	1	no	1 - receive only antenna measurement
noise_bit_setting	4.0	4.0	4.0	no	9 dB setting used by all low SNR scatterometry
dutycycle	don't care	0.38	0.38	no	
prf (Hz)	1200	1200	1200	no	
tro	don't care	6	6	no	automatically set to 6
number_of_pulses	150	150	150	no	Set with the PRF to fill the science data buffer - Only 2 PRI's worth of data are downlinked.
n_bursts_in_flight	1	1	1	no	
percent_of_BW	don't care	0.0	0.0	no	
auto_rad	on	on	on	no	
rip (ms)	34.0	34.0	34.0	no	
max_data_rate	4.300	4.300	4.300	no	
interleave_flag	off	off	off	no	
interleave_duration (min)	don't care	10.0	10.0	no	

Table 5: en_061_1 Div eg scat_compressed block

RADAR instructions are called an Instrument Execution Block (IEB). The IEB is produced by running RMSS with a radar config file that controls the process of generating IEB instructions for different segments of time. These segments of time are called divisions with a particular behavior defined by a set of division keywords in the config file. Table 2 shows a summary of the divisions used in this observation. Subsequent sections will show and discuss the keyword selections made for each division. Each division table shows a set of nominal parameters that are determined by the operating mode (eg., distant scatterometry, SAR low-res inbound). The actual division parameters from the config file are also shown, and any meaningful mismatches are flagged.

3 Receive Only Engineering Test Measurements

Div's E and G (see table 5) provides scatt mode, 9 dB attenuator receive only data off and on target for calibration of the scatterometer tone integration data. All of the receive only data is collected in compressed mode to get more integration time. The PRF and number of pulses are chosen to fill the science data buffer. These parameters give the best performance possible from the compressed mode.

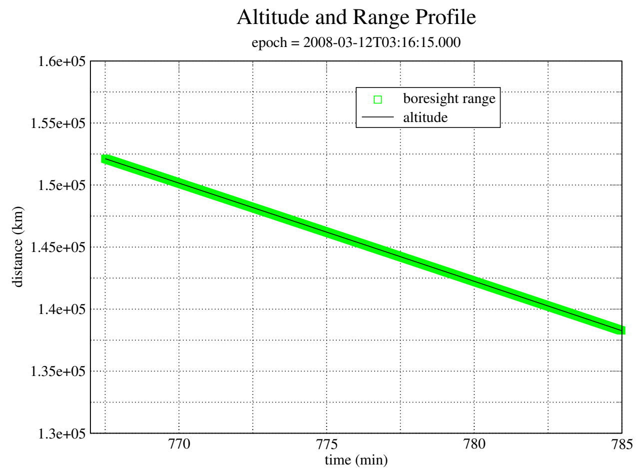

Figure 1: Div H: Altitude and range to the boresight point

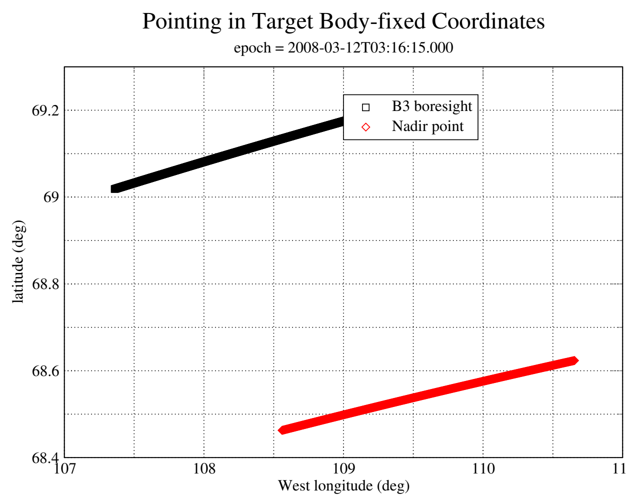

Figure 2: Div H: Stare in target body-fixed coordinates

4 Div H: Enceladus Scatterometry

Figures 1 and 2 show the pointing design for the scatterometry stare from the merged ckernel. The angular size of the target is about 2.3 mrad during this division. The beam 3 beamwidth is 6 mrad. The division parameters for the tone target integration divisions are shown in table **??**. The duty cycle for this observation has been reduced to 0.6 from the usual 0.7 to stay under the burst duty cycle limit of 7%. Normally the burst rate and data rate would be reduced to accomodate this limit; however, for this observation, the interleaving of the multiple bursts in flight does not permit such a reduction.

4.1 Scatterometer Performance

The detection performance is shown in figures 3, 4, and 5. The maximum doppler spread in Div h is 590 Hz which comes from rotation and spacecraft motion. The PRF needs to be higher than the doppler spread to support potential range-doppler processing, and is set by division parameter to 977 Hz. With this PRF, the range amiguity spacing is 153 km while Enceladus is 249 km in radius. The range-spread of the beam depends on where it is pointed. For target centered pointing the cosine law can be applied to solve the geometry. At 152125 km range, the range-spread is 248

Name	Nominal	Actual	Mismatch	Comments
mode	scatterometer	scatterometer	no	
start_time (min)	varies	767.5	no	
end_time (min)	varies	785.0	no	
time_step (s)	don't care	20.0	no	Used when BIF > 1, otherwise set by valid time calculation
bem	00100	00100	no	
baq	5	5	no	
csr	0	0	no	0 - normal operation with fixed attenuator set to match Phoebe for easier cross-calibration
noise_bit_setting	4.0	4.0	no	Scat signal set higher than ALT/SAR
dutycycle	0.70	0.60	yes	
prf (Hz)	varies	977	no	Set to cover doppler spread and to allow CSF = integer multiple
tro	6	6	no	6 - allows for some noise only data in time domain
number_of_pulses	varies	74	no	depends on PRF choice (can have more shorter pulses)
n_bursts_in_flight	varies	2	no	Used to increase PRF and data rate at long range
percent_of_BW	0.0	0.0	no	
auto_rad	on	on	no	
rip (ms)	34.0	34.0	no	
max_data_rate	200.000	220.000	yes	Kbps - determines burst period
interleave_flag	off	off	no	
interleave_duration (min)	don't care	10.0	no	

Table 6: en_061_1 Div h distant_scatterometer block

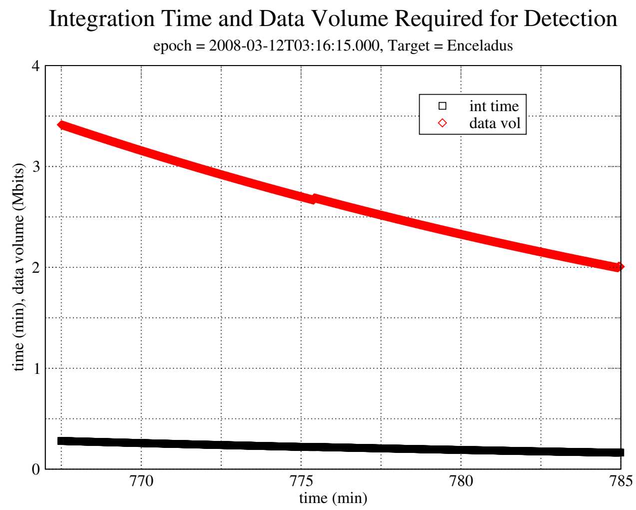

Figure 3: Scatterometry Div H: Detection integration time required for a single point detection using optimal chirp bandwidth

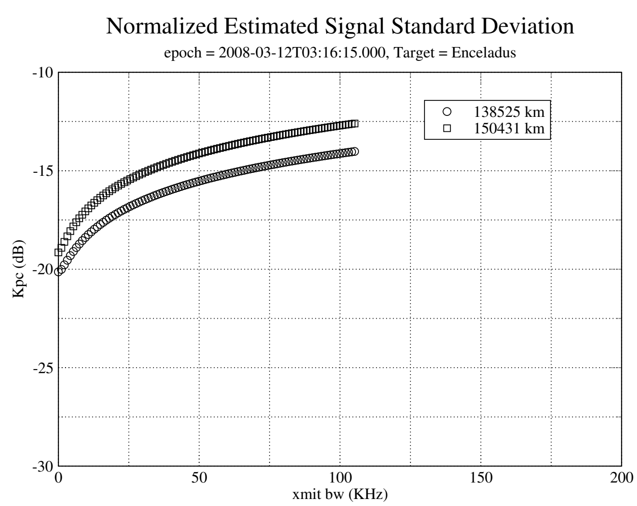

Figure 4: Div H: Normalized estimated signal standard deviation for a disk integrated observation using optimal chirp bandwidth and assuming all the bursts occur at minimum range, and 15 minutes away from minimum range.

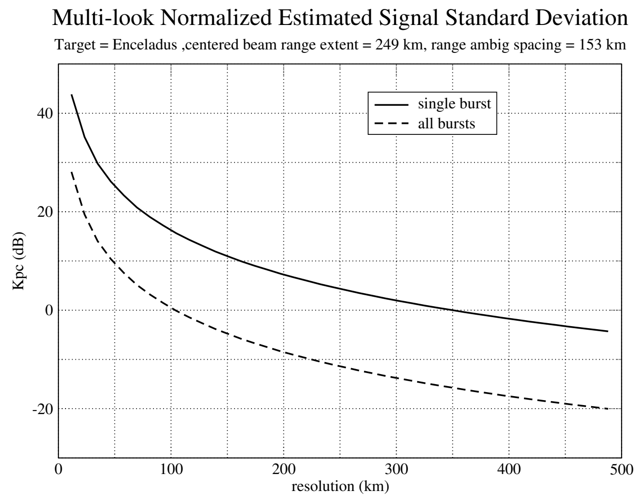

Figure 5: Div H: Normalized estimated signal standard deviation for a range/doppler cell as a function of resolution. Range/doppler resolution elements are both set equal to the specified resolution. Results are shown for a single burst, and for all the bursts in this division. Calculations are performed using the geometry at the start of the division. The presence of ambiguities are not shown.

km. Figure 5 shows that range processing is not possible due to high K_{pc}. Range ambiguity spacing also precludes range processing. Disk integrated results should be very stable.

5 Revision History

1. Dec 29, 2008: Updated for PDS

6 Acronym List

ALT	Altimeter - one of the radar operating modes
BAQ	Block Adaptive Quantizer
CIMS	Cassini Information Management System - a database of observations
Ckernel	NAIF kernel file containing attitude data
DLAP	Desired Look Angle Profile - spacecraft pointing profile designed for optimal SAR performance
ESS	Energy Storage System - capacitor bank used by RADAR to store transmit energy
IEB	Instrument Execution Block - instructions for the instrument
ISS	Imaging Science Subsystem
IVD	Inertial Vector Description - attitude vector data
IVP	Inertial Vector Propagator - spacecraft software, part of attitude control system
INMS	Inertial Neutral Mass Spectrometer - one of the instruments
NAIF	Navigation and Ancillary Information Facility
ORS	Optical Remote Sensing instruments
PDT	Pointing Design Tool
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
RMSS	Radar Mapping Sequencing Software - produces radar IEB's
SAR	Synthetic Aperture Radar - radar imaging mode
SNR	Signal to Noise Ratio
SOP	Science Operations Plan - detailed sequence design
SOPUD	Science Operations Plan Update - phase of sequencing when SOP is updated prior to actual sequencing
SSG	SubSequence Generation - spacecraft/instrument commands are produced
SPICE	Spacecraft, Instrument, C-kernel handling software - supplied by NAIF to use NAIF kernel files.
TRO	Transmit Receive Offset - round trip delay time in units of PRI